M.Sc. PHYSICS
FOURTH SEMESTER
CONDENSED MATTER PHYSICS-II
MSP - 403A

(Use Separate Answer Scripts for Objective & Descriptive)

Duration: 3 hrs. **Full Marks: 70**

(PART-A: Objective)

Time: 20 min. **Marks: 20**

Choose the correct answer from the following: ***1×20=20***

1. $f(E)$ is the probability of occupying a level E. The probability of occupying the level E for a hole is
   a. $f(E)$ b. $1 - f(E)$
   c. $\frac{f(E)}{(1 - f(E))}$ d. $\frac{1 - f(E)}{f(E))}$
2. (B) The electrons with energies higher than the Fermi energy obey (up to a good approximation) the distribution
   a. Fermi-Dirac b. Maxwell-Boltzmann
   c. Bose-Einstein d. random
3. Donor level lies (CB: conduction band, VB: valence band)
   a. just below the CB b. in the CB
   c. just above the VB d. in the VB
4. Acceptor level lies
   a. just below the CB b. in the CB
   c. just above the VB d. in the VB
5. The product $np = n_i^2$, is a constant, independent of
   a. temperature b. doping
   c. both temperature and doping d. none of these
6. Negative differential conductance phenomenon is observed in
   a. photoconductivity b. Gunn effect
   c. thermionic emission d. Hall effect
7. The mobility of an electron is high for
   a. smaller effective mass b. larger effective mass
   c. shorter lifetime d. none of these
8. Fundamental absorption takes place for
   a. $h\nu \ll E_g$ b. $h\nu < E_g$
   c. $h\nu \geq E_g$ d. none of these
9. The width of the depletion region
   a. decreases with increasing the doping concentration b. decreases with decreasing the doping concentration
   c. is independent of doping concentration d. None of these

10. For the hot electrons, the magnitude of the applied field is about
a. 1 V/cm b. 10 V/cm c. 100 V/cm d. 1000 V/cm

11. Which of the following conditions is a must for growth of thin films?
a. Normal pressure
b. Low pressure
c. Room temperature
d. Low mean free path

12. Bombardment and removal of a source material is involved in which of the following processes?
a. Sputtering
b. Chemical vapour deposition
c. Molecular beam epitaxy
d. Vacuum evaporation

13. In which of the following thin film growth processes, volatile precursors are used?
a. Sputtering
b. Chemical vapour deposition
c. Vacuum evaporation
d. Molecular beam epitaxy

14. Volmer-Weber growth involves
a. Island growth followed by layer growth
b. Layer growth followed by island growth
c. Layer growth
d. Island growth

15. Which of the following expressions represents order parameter S?
a. $\frac{1}{2}<\cos^2\theta-3>$
b. $\frac{1}{2}<3\cos^2\theta+1>$
c. $\frac{1}{2}<3\cos^2\theta-1>$
d. $\frac{1}{2}<\cos^2\theta+3>$

16. Which one of the following should be the maximum dimension of a nanomaterial?
a. 10 nm b. 50 nm c. 100 nm d. 1000 nm

17. Which of the following confinements is exhibited by quantum wire structure?
a. 0- dimensional
b. 1- dimensional
c. 2- dimensional
d. 3- dimensional

18. In an SEM, when a high energy electron beam interacts with a sample, which of the following is not generated?
a. Backscattered electrons
b. Primary electrons
c. Characteristic X-rays
d. Secondary electrons

19. How are accelerating potential and spatial resolution related?
a. Larger accelerating potential gives greater resolution
b. Larger accelerating potential gives smaller resolution
c. Greater resolution corresponds to smaller accelerating potential
d. They are unrelated

20. If nanoparticles of a particular semiconductor exhibits an absorption peak at 365 nm, which one of the following is the approximate bandgap of the same?
a. 3.1 eV
b. 3.4 eV
c. 3.2 eV
d. 3.3 eV

-- --- --

PART-B :Descriptive

Time : 2 hrs. 40 min. Marks : 50

[Answer question no.1 & any four (4) from the rest]

1. a. Write down the Fermi-Dirac distribution function $f(E)$ mentioning each term. Draw $f(E)$ versus E at three different temperatures including the absolute zero case. Discuss the possible cases at absolute zero temperature. **6+4=10**

   b. Semiconductors usually contain both donors and acceptors. Name the processes through which electrons and holes are created with a band diagram, which includes CB, VB, acceptor and donor levels.

2. a. Define the density of states (DOS) $g(E)$. **2+8=10**

   b. Show that $(E) = \frac{1}{2\pi^2}\left(\frac{2m^*}{\hbar^2}\right)^{\frac{3}{2}} E^{\frac{1}{2}}$, where the symbols have their usual meanings.

3. a. Discuss the diffusion process under different circumstances, namely, (i) behavior of concentration pulse with space at different times, (ii) the same as (i) in the presence of an electric field, and (iii) the same as (i) now with considering recombination. **5+5=10**

   b. Draw the various absorption processes involving impurities through the band diagrams.

4. a. Discuss the photoconductivity phenomenon with proper diagram. **4+6=10**

   b. Find out the excess carriers using the rate equation in terms of the generation rate and recombination process.

5. a. What is an epitaxy process? **2+8=10**

   b. Explain molecular beam epitaxy process for growth of thin films.

6. a. Explain nucleation and growth of thin films. **4+2+4 =10**

   b. What are liquid crystals?

   c. Explain different phases of liquid crystals.

7. a. What is Bohr exciton radius? Explain with an appropriate figure. **3+3+4 =10**

   b. What are weak, intermediate and strong confinements?

   c. What are some advantages of nanomaterials over their bulk counterparts?

8. a. Explain the importance of an electron microscope over optical ones. 2+3+5 =10

b. Explain the working theory of a transmission electron microscope.

c. How are morphology and chemical composition analysis done by a scanning electron micrioscope?

= = *** = =